End of Result Set

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L2: Entry 2 of 2 File: USPT Jan 27, 1998

US-PAT-NO: 5712985
DOCUMENT-IDENTIFIER: US 5712985 A

TITLE: System and method for estimating business demand based on business influences

DATE-ISSUED: January 27, 1998

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Lee; Michael D.	Albuquerque	NM	87124	
Fields; Randall K.	Park City	UT	84060	
Pond; Jamie T.	Salt Lake City	UT	84109	
Tondevold; Barrire K.	Murray	UT	84123	

APPL-NO: 08/ 542847 [PALM]
DATE FILED: October 13, 1995

PARENT-CASE:
RELATED APPLICATION This application is a continuation in part of application Ser. No. 08/023,111, filed on Feb. 26, 1993, now U.S. Pat. No. 5,459,656 entitled BUSINESS DEMAND ESTIMATION SYSTEM, incorporated by referenced herein, which is a continuation in part of application Ser. No. 07/808,982, filed on Dec. 17, 1991, entitled PRODUCT DEMAND SYSTEM AND METHOD which is a continuation application of Ser. No. 07/406,069, filed on Sep. 12, 1989, entitled PRODUCT DEMAND SYSTEM AND METHOD, all of which are commonly owned by the assignee.

INT-CL: [06] G06 F 17/60

US-CL-ISSUED: 395/207; 395/210, 395/208, 364/468.01, 364/468.02, 364/468.03
US-CL-CURRENT: 705/7; 700/95, 700/96, 700/97, 705/10, 705/8

FIELD-OF-SEARCH: 395/208, 395/210, 395/207, 364/468.01, 364/468.02, 364/468.03

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected | Search ALL

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	4141069	February 1979	Fox	364/493
☐	5111391	May 1992	Fields et al.	395/209
☐	5224034	June 1993	Katz et al.	395/207
☐	5255181	October 1993	Chapman et al.	395/208
☐	5287267	February 1994	Jayaraman et al.	395/210
☐	5299115	March 1994	Fields et al.	395/210
☐	5440480	August 1995	Costanza	395/208
☐	5446890	August 1995	Renslo et al.	395/600
☐	5459656	October 1995	Fields et al.	395/207
☐	5615109	March 1997	Eder	395/207

OTHER PUBLICATIONS

STSC Inc.; Mar. 16, 1987. Acc. #00152990, File 621.
"Optimal production planning . . . " by Bartmann, D.; Oct. 1983 Acc. #02301025 file #2.

ART-UNIT: 241

PRIMARY-EXAMINER: Hayes; Gail O.

ASSISTANT-EXAMINER: Shingala; Gita

ATTY-AGENT-FIRM: Fenwick & West LLP

ABSTRACT:

A demand forecasting and production scheduling system and method creates production schedules for various business items describing a forecasted demand for the business items in a number of future time intervals. The system includes a computer managed database of various profiles, including a base profile for each business item, and a number of influence profiles. The profiles describe variations in demand for the business item in a number of time intervals. The base profile describes an underlying level of demand for a business item that is anticipated for the business item absent any influencing factors, such as promotional sales, holidays, weather variations, and the like. The variations in demand for the business item due to such influence factors are stored in the database as influence profiles. The influence profiles may be either standard, percentage, or seasonal. The forecasted demand for a business item in a number of future time intervals is determined by selective combination of the base profile for the business item and any number of influence profiles. The forecasted demand is stored in the database in a forecast profile. From the forecast profile a production schedule is created, and the business item provided according to the production schedule. Actual demand for the business item is monitored and stored. The variation between actual demand and the forecasted demand is used to update the base and influence profiles. From the updated base and influence profiles the forecasted demand is redetermined, and the production schedule updated accordingly.

48 Claims, 6 Drawing figures

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End of Result Set

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L2: Entry 2 of 2 File: USPT Jan 27, 1998

DOCUMENT-IDENTIFIER: US 5712985 A
TITLE: System and method for estimating business demand based on business influences

Application Filing Date (1):
19951013

Detailed Description Text (73):
Likewise, for a retail store providing consumables, such as a fast food restaurant, production would include making the business items (e.g. cookies, hamburgers, tacos, and the like) in the forecasted quantities at the specified future time intervals. In this type of retail environment, demand fluctuates significantly throughout the day, and there is a need to provide the business items, which are perishable, only at or about the time when demand is forecasted. Accordingly, in this environment, the production schedule of forecasted demand is particularly useful, and would indicate in hourly, quarter-hourly, or other useful interval, the quantity forecasted for each business item offered by the establishment. In addition, the production schedule may be used interactively such an embodiment to provide employees of the business with the forecasted demand levels at some predetermined amount of time prior to the forecasted demand interval so that the business item may be produced in time to meet the forecasted demand.

Current US Cross Reference Classification (4):
705/10

Current US Cross Reference Classification (5):
705/8

End of Result Set

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L2: Entry 2 of 2 File: USPT Jan 27, 1998

DOCUMENT-IDENTIFIER: US 5712985 A
TITLE: System and method for estimating business demand based on business influences

Application Filing Date (1):
19951013

Detailed Description Text (73):
Likewise, for a retail store providing consumables, such as a fast food restaurant, production would include making the business items (e.g. cookies, hamburgers, tacos, and the like) in the forecasted quantities at the specified future time intervals. In this type of retail environment, demand fluctuates significantly throughout the day, and there is a need to provide the business items, which are perishable, only at or about the time when demand is forecasted. Accordingly, in this environment, the production schedule of forecasted demand is particularly useful, and would indicate in hourly, quarter-hourly, or other useful interval, the quantity forecasted for each business item offered by the establishment. In addition, the production schedule may be used interactively such an embodiment to provide employees of the business with the forecasted demand levels at some predetermined amount of time prior to the forecasted demand interval so that the business item may be produced in time to meet the forecasted demand.

Current US Cross Reference Classification (4):
705/10

Current US Cross Reference Classification (5):
705/8

End of Result Set

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L17: Entry 1 of 1 File: USPT Jan 27, 1998

DOCUMENT-IDENTIFIER: US 5712985 A
TITLE: System and method for estimating business demand based on business influences

US Patent No. (1):
5712985

Detailed Description Text (73):
Likewise, for a retail store providing consumables, such as a fast food restaurant, production would include making the business items (e.g. cookies, hamburgers, tacos, and the like) in the forecasted quantities at the specified future time intervals. In this type of retail environment, demand fluctuates significantly throughout the day, and there is a need to provide the business items, which are perishable, only at or about the time when demand is forecasted. Accordingly, in this environment, the production schedule of forecasted demand is particularly useful, and would indicate in hourly, quarter-hourly, or other useful interval, the quantity forecasted for each business item offered by the establishment. In addition, the production schedule may be used interactively such an embodiment to provide employees of the business with the forecasted demand levels at some predetermined amount of time prior to the forecasted demand interval so that the business item may be produced in time to meet the forecasted demand.

End of Result Set

Generate Collection | Print

L19: Entry 1 of 1 File: USPT Jan 27, 1998

DOCUMENT-IDENTIFIER: US 5712985 A
TITLE: System and method for estimating business demand based on business influences

US Patent No. (1):
5712985

Detailed Description Text (9):
The user authors 201 a plurality of base profiles and influence profiles that describe the relationships between the business items, time intervals, and actual demand data. The base profiles and the influence profiles are drawn from an analysis of actual demand data in the actual demand data file. 15 which stores the demand for the item on an interval basis. The user may additionally chose to author variables describing production capacity and staffing requirements of the business location, along with other location specific or relevant production variables.

End of Result Set

Generate Collection | Print

L20: Entry 1 of 1 File: USPT May 13, 1997

US-PAT-NO: 5630070
DOCUMENT-IDENTIFIER: US 5630070 A

TITLE: Optimization of manufacturing resource planning

DATE-ISSUED: May 13, 1997

INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
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Wittrock; Robert J.	Ossining	NY		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
International Business Machines Corporation	Armonk	NY			02

APPL-NO: 08/ 108014 [PALM]
DATE FILED: August 16, 1993

INT-CL: [06] G06 F 17/60

US-CL-ISSUED: 395/208
US-CL-CURRENT: 705/8

FIELD-OF-SEARCH: 364/401, 364/402, 304/41R, 304/402, 395/207-208, 395/210

PRIOR-ART-DISCLOSED:

U.S. PATENT DOCUMENTS

Search Selected | Search ALL

	PAT-NO	ISSUE-DATE	PATENTEE-NAME	US-CL
☐	4646238	February 1987	Carlson, Jr. et al.	364/403
☐	4744026	May 1988	Vanderbei	364/402
☐	4744027	May 1988	Bayer et al.	364/402
☐	4885686	December 1989	Vanderbei	364/402
☐	4924386	May 1990	Freedman et al.	364/402
☐	5053970	October 1991	Kurihara et al.	364/468
☐	5093794	March 1992	Howie et al.	364/468
☐	5101352	March 1992	Rembert	364/401
☐	5140537	August 1992	Tullis	364/578
☐	5148370	September 1992	Litt et al.	364/468
☐	5155679	October 1992	Jain et al.	364/402
☐	5172313	December 1992	Schumacher	364/401
☐	5185715	February 1993	Zikan et al.	364/807
☐	5216593	June 1993	Dietrich et al.	364/402

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
0364090	August 1989	EP	
0517953A2	December 1991	EP	

OTHER PUBLICATIONS

"Molp with an Interactive Assessment of a Piecewise Linear Utility Function", Jacquet-Lagreze et al, European Journal of Operational Research, vol. 31, 1987, pp. 350-357.
"A Hybrid Approach to Multi-Objective Linear Optimization", Poh et al., Journal of the Operational Research Society, vol. 41, No. 11, 1990, pp. 1037-1048.
"A Weighted-Gradient Approach to Multi-Objective Linear Programming Problems Using the Analytic Hierarchy Process", Arbel, Mathematical and Computer Modelling, vol. 14, No. 4/5, 1993, pp. 27-39.
"Determination of the Crop Mix of a Rubber and Oil Plantation--A Programming Approach", Tan et al., European Journal of Operational Research, vol. 34, 1988, pp. 362-371.

ART-UNIT: 241

PRIMARY-EXAMINER: Hayes; Gail O.

ASSISTANT-EXAMINER: Kyle; Charles

ATTY-AGENT-FIRM: Perman & Green

ABSTRACT:

A method for constrained material requirements planning, optimal resource allocation, and production planning provides for an optimization of a manufacturing process by designating the amounts of various manufactured products to be produced, which products include both end products as well as subassemblies to be employed in the manufacture of one or more of the end products. In order to accomplish the optimization, the method employs an objective function such as the maximization of income in a situation wherein there are limitations on the inventory of raw materials and tools to be employed in the manufacturing process. Data describing

elemental steps in the manufacturing process for the production of each end product, as well as the quantity or demand for each end product which is to be supplied, are presented as a set of linear mathematical relationships in matrix form to be inserted in a computer which determines the optimum number of each end product in accordance with an LP optimization algorithm. The matrix contains bill of material data, and various constraints such as a constraint on the sum of products shipped and used as subassemblies, and constraints based on inventory, on available time for use of resources such as tools, and on inventory left over from an early production run for a later run.

23 Claims, 10 Drawing figures

End of Result Set

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L22: Entry 1 of 1 File: USPT May 13, 1997

DOCUMENT-IDENTIFIER: US 5630070 A
TITLE: Optimization of manufacturing resource planning

Abstract Text (1):
A method for constrained material requirements planning, optimal resource allocation, and production planning provides for an optimization of a manufacturing process by designating the amounts of various manufactured products to be produced, which products include both end products as well as subassemblies to be employed in the manufacture of one or more of the end products. In order to accomplish the optimization, the method employs an objective function such as the maximization of income in a situation wherein there are limitations on the inventory of raw materials and tools to be employed in the manufacturing process. Data describing elemental steps in the manufacturing process for the production of each end product, as well as the quantity or demand for each end product which is to be supplied, are presented as a set of linear mathematical relationships in matrix form to be inserted in a computer which determines the optimum number of each end product in accordance with an LP optimization algorithm. The matrix contains bill of material data, and various constraints such as a constraint on the sum of products shipped and used as subassemblies, and constraints based on inventory, on available time for use of resources such as tools, and on inventory left over from an early production run for a later run.

US Patent No. (1):
5630070

Brief Summary Text (5):
One method of representing such allocation decision problems is known as a linear programming model. Such a model consists of a number of linear relationships, set forth in matrix format, and representing quantitatively the relationships among allocations, constraints and results of an industrial or other technological process. In the linear relationships, there is provided the sum of constant coefficients multiplied by unknown allocation values. While many resource allocation problems are not represented by such linear relationships, but involve higher powers or other nonlinear expression of equation variables, the optimization of MRP processes has been treated by a linear model. Such modeling by linear programming (LP) is accomplished in multidimensional space with multidimensional vectors providing a multidimensional figure, or polytope, wherein each facet on a surface thereof is bounded by equations defining relationships among allocated inputs to the industrial process. An optimum solution to the LP problem has been obtained by use of the Simplex algorithm developed by George Dantzig in 1947, by way of example, or by the more recent Karmarkar algorithm, as disclosed in U.S. Pat. No. 4,924,386 of Freedman et al.

Brief Summary Text (15):
In accordance with the invention, data describing elemental steps in the manufacturing process for the production of each end product, as well as the quantity or demand for each end product which is to be supplied, are presented as a set of linear mathematical relationships in matrix form to be inserted in a computer which determines the optimum number of each end product in accordance with an LP optimization algorithm such as the aforementioned Simplex, as implemented by well-known commercially available OSL or MPSX programs in the practice of a preferred embodiment of the invention, or by the aforementioned Karmarkar algorithm. The results of the optimization are then incorporated with other manufacturing data generally found in an MRP to enable a manufacturer to determine an optimal shipping

schedule, the corresponding production schedule, as well as a part usage schedule.

Detailed Description Text (29):
These two sets of constraints describe the set of all possible combinations of products that can be made with the available ingredients. Note that these constraints permit combinations that are inconsistent with the product demand. For example, the point x.sub.1 =12, x.sub.2 =12, x.sub.3 =0, x.sub.4 =0, x.sub.5 =0, x.sub.6 =0, x.sub.7 =0, x.sub.8 =0, x.sub.9 =0, x.sub.10 =0, which corresponds to making 12 cheese omelets and 12 plain omelets that are used in the cheese omelets and none of the other items, satisfies all of the material availability constraints and the non-negativity constraints. However, since the demand for cheese omelets is only 4, the point (12, 12, 0,0,0,0,0,0,0,0) is not likely to represent a good allocation of the available ingredients.

Detailed Description Text (59):
The A matrix has ten columns on the left part of the matrix for the ten components of the variable x as set forth in the equation set (1), and nine columns on the right part of the matrix for the nine components of the variable s as set forth in the equation sets (3) and (4). The coefficients of the first eight rows are the same as the coefficients of the x components as set forth in the first eight lines of equation set (1). The coefficients in the ninth row of the matrix correspond to the coefficients of the ninth line of the equation set (1) such that the coefficients of the first five columns in the ninth row of the matrix are the same as the five x coefficients of the ninth line of the equation set (1), and the coefficient of the first s column of the matrix is the same as the coefficient of the sole s component in the ninth line of the equation set (1). The entries at the right side of the inequality signs in the nine lines of equation set (1) are found in the corresponding nine places of the b vector of FIG. 8. The next eight rows (row 10 through row 17) of the A matrix have coefficients which are the same as the coefficients of the x and the s components set forth in the eight lines of equation set (3). The entries at the right side of the inequality signs in the eight lines of equation set (3) are found in the corresponding eight places of the b vector. In similar fashion, the entries in the last nine rows of the A matrix and the last nine places of the b vector correspond to the entries in the nine lines of equation set (4). Note that the upper left hand corner of A gives the bill of material, that is, if the row i corresponds to material i and the column j corresponds to the production of product j then aij (the entry in the ith row, jth column of A) is usage of material in i product j. The upper portion of the b vector corresponds to the availability of materials, while the lower portion of the b vector corresponds to demands.

Detailed Description Text (393):
Specifically, in Step 1, demand data, bill-of-material data, and inventory data are extracted from an MRP system or other manufacturing information system, bill-of-resource data and resource availability data are extracted from a CRP system or other manufacturing information system, and cost and revenue data is extracted from the MRP system, the CRP system, or some other manufacturing information system. In Step 2, the Optimal Resource Allocation Procedure processes this data, formulates the Linear Program, invokes an LP solver, extracts the optimal values of the LP variables, translates these values in to a shipment schedule and a production schedule. In addition, the "dual variable" are also extracted from the LP solver, and those corresponding to material availability constraints and capacity availability constraints are sorted in decreasing order. Among this set, the constraint with the largest dual variable corresponds to a capacity or material, and a time period such that obtaining more of that capacity or resource in that time period will have the greatest impact on total profit. A list of pairs (material or resource, time period) that have the most potential for impacting profit are reported.

Detailed Description Text (395):
Specifically, in Step 1, demand data, bill-of-material data, and inventory data are extracted from MRP system or other manufacturing information system, bill-of-resource data and resource availability data are extracted from a CRP system or other manufacturing information system, and cost and revenue data is extracted from the MRP system, the CRP system, or some other manufacturing information system. Inventory data is extracted for on-hand and firm order inventory only. The demand data is adjusted, if necessary, to reflect potential demand for each of the possible end products. The holding cost of each material in the final period is set to the value of that material; all other cost and revenue data is eliminated. In Step 2,

the Optimal Resource Allocation Procedure processes this data and formulates the Linear Program. The then LP solver is invoked, and the optimal values of the Lp variables are extracted and translated into a shipment schedule and a production schedule. Since the only coefficients in the objective function are holding costs for inventory in the final period, production and shipment schedule correspond to an allocation of resources that minimizes the value of the final inventory.

CLAIMS:

8. A method according to claim 7 wherein said manufacture is accomplished with the use of a set of resources, each resource of said set of resources being available for a predetermined amount of time, the method further comprising

establishing additional resource-constraint rows in said matrix and corresponding additional resource-constraint locations in said vector;

for each of the products employing, in its manufacture, one of said resources, totaling the usage time for each product of said one resource, and setting forth a relationship in the matrix row of said one resource providing for said totaling of resource usage time, said totaling of resource usage time being less than or equal to a maximum amount of resource usage time set forth in the corresponding resource constraint location of said vector.

10. A method according to claim 1 wherein said manufacture is accomplished with the use of a set of resources, each resource of said set of resources being available for a predetermined amount of time, the method further comprising

establishing additional resource-constraint rows in said matrix and corresponding additional resource-constraint locations in said vector;

for each of the products employing, in its manufacture, one of said resources, totaling the usage time for each product of said one resource, and setting forth a relationship in the matrix row of said one resource providing for said totaling of resource usage time, said totaling of resource usage time being less than or equal to a maximum amount of resource usage time set forth in the corresponding resource constraint location of said vector.

22. A method for material constrained production planning whereby a feasible allocation of material to demand for maximization of profit is determined to obtain an optimum production quantity for each of said product types, the material including components in a plurality of manufacturing procedures conducted in accordance with a manufacturing information system for said optimum production quantity, the method comprising steps of:

providing demand data, bill-of-resource data, resource availability data, cost and revenue data;

within each of said procedures, establishing quantities of components to be employed in respective ones of said procedures;

providing an inventory of said components from said data, and placing each type of component of the inventory in a separate location of a vector;

arranging said products as variables in respective product columns of a matrix having rows and columns wherein individual ones of the rows are reserved for respective components of the products, there being a plurality of product columns with a separate column for each product type;

establishing a material constraint for the set of components of the respective component rows by, in each of the component rows, multiplying the product variable of each column by coefficients designating the amount of each component in the product, each of the component rows corresponding to the location of an amount of component type in the vector;

via a plurality of production constraints for said products, constraining shipments of respective ones of said product types minus the quantity of each of the respective product types produced to be less than or equal to a quantity of each of the product types in inventory;

placing said production constraints of said product types in respective ones of additional rows of the matrix with shipments being located in separate shipment columns of the matrix and said product types being located in the respective product columns, there being a separate row for each product type having a nonzero shipment, the quantities of the product types in inventory being entered at locations of said vector corresponding to the matrix row having the production constraints;

via a plurality of demand constraints for said products, constraining shipments of respective ones of said product types to be less than or equal to a demand for the respective product types;

placing said demand constraints of said products in separate additional rows of said matrix with shipments being located in respective ones of said shipment columns of the matrix, the demands for said product types being located in separate locations of said vector corresponding to the respective rows of the demand constraints;

wherein said manufacture is accomplished with the use of a set of resources, each resource of said set of resources being available for a predetermined amount of time, the method further comprising

establishing additional resource-constraint rows in said matrix and corresponding additional resource-constraint locations in said vector;

for each of the products employing, in its manufacture, one of said resources, totaling the usage time for each product of said one resource, and setting forth a relationship in the matrix row of said one resource providing for said totaling of resource usage time, said totaling of resource usage time being less than or equal to a maximum amount of resource usage time set forth in the corresponding resource constraint location of said vector;

applying a linear programming optimization to said matrix and said vector in accordance with an objective function to obtain said optimum production quantity for each of said product types to maximize profit;

providing a shipment schedule and a production schedule; and

inserting the shipment schedule and the production schedule into said manufacturing information system for a manufacture of each of said product types in said optimum production quantity.

End of Result Set

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L21: Entry 1 of 1 File: USPT May 13, 1997

DOCUMENT-IDENTIFIER: US 5630070 A
TITLE: Optimization of manufacturing resource planning

US Patent No. (1):
5630070

Detailed Description Text (8):
In the ensuing description of the preparation of food products by the restaurant, tabulated data for the various forms of the omelets and the sandwiches will be presented in a set of tables wherein Table 1 presents the cost or selling price for each food item outputted by the manufacturing process, as well as recipes for each food item. The recipes are set forth in a format analogous to a manufacturing process employing raw materials plus previously completed subassemblies. For example, the vegetable omelet is described as being composed of raw materials, namely two ounces of mushrooms and two ounces of green peppers, plus a single subassembly, namely one plain omelet. To calculate the total amount of raw materials consumed in the production of the vegetable omelet, one must consider both the raw materials listed in the recipe plus the raw materials employed in producing the subassembly of the plain omelet; this gives two ounces of mushrooms, two ounces of green peppers, three eggs, and one teaspoon of butter. Such a break-out of the amounts of all of the raw materials employed in production of an end product, often referred to as an explosion in the language of MRP, is employed in listing the total amount of each ingredient, or raw material, as will be described with reference to Table 4, to meet the demands by customers for various food products as set forth in Table 2.

Detailed Description Text (9):
For example, Table 2 shows that the customers have ordered six of the vegetable omelets. Accordingly, the foregoing quantities of each of the four ingredients of the vegetable omelet would be multiplied by six to obtain the total amount of raw materials employed in meeting the customer demand for vegetable omelet. Similar calculations would be employed for each of the other food products, and the results are to be summed together to give a grand total of the quantities of the raw materials of all the demanded food products. In the event that the restaurant has a cheese sandwich left over from a previous production run, which sandwich is to be used to meet the present customer demand, then the total amount of raw materials required for the present production run can be reduced by the amount in the left-over cheese sandwich. Similarly, if there were left-over plain sandwiches (just two slices of bread per sandwich), the amount of bread required to meet the customer demand would be reduced by the amount of bread in the plain sandwiches. Table 3 lists the inventory available to the cook at the beginning of the production run. As will be seen in the following example, there is an insufficiency, or shortage, for each ingredient except for mushrooms wherein there is an excess, as indicated in Table 5. Note that, in Table 5, the amount of the shortage of mushrooms is shown as zero to avoid the appearance of negative amounts in the ensuing mathematical explanation. The example of the restaurant is as follows.

Detailed Description Text (10):
In order to illustrate the differences between standard MRP and constrained production planning, there is provided the following relatively simple example. A cook makes 2 types of foods, omelets and sandwiches. He makes 5 types of omelets and 5 types of sandwiches, using a total of 7 ingredients (eggs, bread, butter, ham, cheese, peppers and mushrooms). He has a set of customer orders for his omelets and sandwiches and a fixed set of ingredients on hand. The receipts, and the selling

price of his products are shown in Table 1.

Detailed Description Text (12):
Table 2 gives demand, Table 3 gives inventory. Note that the cook has some finished goods inventory (1 cheese sandwich) and some subassembly inventory (3 plain sandwiches). Table 4 gives the total requirements for the raw ingredients (subassembly and finished goods stock are netted). Table 5 gives the net requirements for the raw ingredients. The information in Table 5 is the usual output of MRP. It tells the manufacturer what additional materials are required in order to meet the end product demand.

Detailed Description Text (26):
Equation set (1) has nine lines corresponding to the nine constraints. The variables to the left of the inequality sign are arranged so that variables representing the same food product in a plurality of the lines appear in the same column. The column of variables to the right of the inequality signs are recognized as being the inventory of Table 3. The first seven lines relate to the seven raw food ingredients of the inventory, and the last two lines relate to the two subassemblies (plain omelet and plain sandwich) of the inventory. In the first ten columns of variables from the left, each column represents a specific one of the food products to be manufactured as listed in Table 1. Also, the first seven row elements of each column, presents the ingredients, exclusive of any required subassembly, for producing the food product. The coefficient for each variable designates the quantity of the food product to be employed in accordance with the recipes of Table 1. The first column of variables at the left side of the equation set discloses, in its first seven row elements, the amount of eggs and butter to be employed in making a single plain omelet. The second column of variables from the left discloses, in its first seven row elements, the amount of cheese to produce a single cheese omelet. In similar fashion, the remaining ones of the first ten columns from the left, in their respective first seven row elements, disclose ingredients for the remaining food products of Table 1.

Detailed Description Text (28):
With respect to equation set (2), it is noted that in the production of any one of the foregoing ten food products of Table 1, the number produced cannot be less than zero. This presents a set of non-negativity constraints for production of the food products which are set forth in equation set 2. The variables representing the respective food products are set forth individually in separate lines of the equation set, and are arranged in columnar form corresponding to the columns of equation set 1. ##STR1##

Detailed Description Text (61):
wherein the coefficients of the s components are the prices of the various food products as set forth in Table 1. We let c denote the vector (2, 3, 3.5, 4, 2.75, 1.5, 2.5, 3, 3.5) wherein the vector components are the set of prices. The problem of determining the revenue maximizing production and shipment schedule then becomes a maximizing of the dot product, namely, ##EQU4##

Detailed Description Paragraph Table (1):
TABLE 1 ______________________________________ Plain omelet $2.00 Plain sandwich $1.00 3 eggs 2 slices bread 1 tsp butter Cheese omelet $3.00 Cheese sandwich $1.50 1 plain omelet 1 plain sandwich 3 oz. cheese 3 oz. cheese Ham omelet $3.50 Ham sandwich $2.50 1 plain omelet 1 plain sandwich 3 oz. ham 3 oz. ham Ham & Cheese $4.00 Ham & cheese $2.50 omelet sandwich 1 plain omelet 1 plain sandwich 2 oz. cheese 2 oz. ham 2 oz. ham 2 oz. cheese Vegetable omelet $2.75 Ham & egg sandwich $3.50 1 plain omelet 1 plain sandwich 2 oz. mushrooms 1 egg 2 oz. green pepper 1 oz. ham ______________________________________

Detailed Description Paragraph Table (2):
TABLE 2 ______________________________________ Demand ______________________________________ Plain omelet 2 Cheese omelet 4 Ham omelet 5 Ham & cheese omelet 2 Vegetable omelet 6 Plain sandwich 0 Cheese sandwich 4 Ham sandwich 3 Ham & cheese sandwich 5 Ham & egg sandwich 4 ______________________________________

Detailed Description Paragraph Table (3):
TABLE 3 ______________________________________ Inventory ______________________________________ Plain sandwich 3 Green pepper 10 oz. Mushroom 14 oz. Butter 15 oz. Eggs 40 Ham 30 oz. Cheese 30 oz. Bread 20 slices Cheese

sandwich 1 ______________________________________

Detailed Description Paragraph Table (4):
TABLE 4 ______________________________________ Total Requirements for raw ingredients ______________________________________ Green pepper 12 oz. Mushroom 10 oz. Butter 19 tsp. Eggs 61 Ham 42 oz. Cheese 35 oz. net 35 (1 cheese sand. invent.) Bread 24 slices - 24 (net 3 plain sand. invent.)

____

Detailed Description Paragraph Table (5):
TABLE 5 ______________________________________ Net Requirements (shortages) ______________________________________ Green pepper 2 oz. Mushrooms 0 (excess inventory) Butter 4 tsp. Eggs 21 Ham 12 oz. Cheese 5 oz. Bread 4 slices

____

For. ref. 10/077364

10/29

WEST

End of Result Set

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L15: Entry 5 of 5 File: DWPI Jan 13, 1976

DERWENT-ACC-NO: 1976-A8720X
DERWENT-WEEK: 197604

TITLE: Electronic cooker with automatic digital timer - compares number of pulses from variable period pulse generator with set value

PATENT-ASSIGNEE: TOKYO SHIBAURA ELECTRIC CO (TOKE)

PRIORITY-DATA: 1973JP-0044833 (April 20, 1973)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
US 3932723 A	January 13, 1976		000	
CA 1036227 A	August 8, 1978		000	

INT-CL (IPC): H05B 9/06

ABSTRACTED-PUB-NO: US 3932723A
BASIC-ABSTRACT:

The electronic range is provided with a high frequency generator, and has a device including quantity setting switches for setting a value representing the quantity of food being cooked, a device for indicating the set value in the form of digits, a pulse generator having a time constant circuit and a device including kind setting switching means for varying the time constant of the time constant circuit in accordance with the kind of food. A counter adds the number of pulses generated from the pulse generator upon the commencement of heating; and a control device brings the operation of the high frequency generator to an end when a prescribed relationship arises between the counts made by the counter and the set value.

ABSTRACTED-PUB-NO: US 3932723A
EQUIVALENT-ABSTRACTS:

DERWENT-CLASS: X25 X26

WEST

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L15: Entry 5 of 5 File: DWPI Jan 13, 1976

DERWENT-ACC-NO: 1976-A8720X
DERWENT-WEEK: 197604

TITLE: Electronic cooker with automatic digital timer - compares number of pulses from variable period pulse generator with set value

Basic Abstract Text (1):
The electronic range is provided with a high frequency generator, and has a device including quantity setting switches for setting a value representing the quantity of food being cooked, a device for indicating the set value in the form of digits, a pulse generator having a time constant circuit and a device including kind setting switching means for varying the time constant of the time constant circuit in accordance with the kind of food. A counter adds the number of pulses generated from the pulse generator upon the commencement of heating; and a control device brings the operation of the high frequency generator to an end when a prescribed relationship arises between the counts made by the counter and the set value.

PF Publication Date (1):
19760113

PF Publication Date (2):
19780808

WEST

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L15: Entry 4 of 5 File: DWPI Dec 2, 1987

DERWENT-ACC-NO: 1987-336951
DERWENT-WEEK: 198748

TITLE: Controlling operation of cooking appts. - computing value corresp. to thermal capacity of food in appts. from detected temp. and elapsed period

INVENTOR: MIYAKE, K

PATENT-ASSIGNEE: MIWA Y (MIWAI), TOSHIBA HEATING APPLIANC (TOSHN), TOSHIBA KK (TOKE)

PRIORITY-DATA: 1986JP-0108338 (May 12, 1986)

PATENT-FAMILY:

PUB-NO	PUB-DATE	LANGUAGE	PAGES	MAIN-IPC
GB 2191024 A	December 2, 1987		010	
GB 2191024 B	May 2, 1990		000	
US 4818547 A	April 4, 1989		011	

APPLICATION-DATA:

PUB-NO	APPL-DATE	APPL-NO	DESCRIPTOR
GB 2191024A	May 7, 1987	1987GB-0010844	
US 4818547A	May 12, 1987	1987US-0048937	

INT-CL (IPC): A23L 1/01; A47J 27/00; H05B 1/02

ABSTRACTED-PUB-NO: GB 2191024A
BASIC-ABSTRACT:

The operating method comprises the steps of heating a quantity of food material (19) to a prescribed set temperature (Q) in the cooking apparatus (10). The heating is stopped for a first predetermined period (T2) to allow the food material (19) to lose heat. Heat is applied to the food material (19) for a second prescribed period (T3) and the actual temperature (R) of the food material is detected.

The time period (T4) elapsed until the actual temperature is detected is measured and a value corresponding to the thermal capacity of the food material in the cooking apparatus is computed from the detected temperature (R) and the elapsed time period (T4). The temperature of the food material in the cooking apparatus is raised to a prescribed cooking temperature for a period (T5) corresponding to the computed value.

USE/ADVANTAGE - Rice and water, soyabeans and water. Cooking time can be more accurately determined.

ABSTRACTED-PUB-NO: GB 2191024B
EQUIVALENT-ABSTRACTS:

The operating method comprises the steps of heating a quantity of food material (19) to a prescribed set temperature (Q) in the cooking apparatus (10). The heating is stopped for a first predetermined period (T2) to allow the food material (19) to lose heat. Heat is applied to the food material (19) for a second prescribed period (T3) and the actual temperature (R) of the food material is detected.

The time period (T4) elapsed until the actual temperature is detected is measured and a value corresponding to the thermal capacity of the food material in the cooking apparatus is computed from the detected temperature (R) and the elapsed time period (T4). The temperature of the food material in the cooking apparatus is raised to a prescribed cooking temperature for a period (T5) corresponding to the computed value.

USE/ADVANTAGE - Rice and water, soyabeans and water. Cooking time can be more accurately determined.

US 4818547A

The food measuring method includes the steps of heating a quantity of food material to a prescribed set temperature in the cooking apparatus, stopping the heating for a predetermined period for radiating heat from the food material, applying heat to the food material for a prescribed period. The actual temperature of the food material, is detected. A value corresponding to the thermal capacity of the material in the cooking apparatus is computed from the detected temperature and the elapsed time.

A cooking operation is started in the cooking apparatus at a time corresponding to the computed value.

USE - Soybeam cooking. (11pp)c

CHOSEN-DRAWING: Dwg.1/8 Dwg.1/8

DERWENT-CLASS: P28 X25 X27
EPI-CODES: X25-B04; X27-C04;

Generate Collection Print

L15: Entry 4 of 5 File: DWPI Dec 2, 1987

DERWENT-ACC-NO: 1987-336951
DERWENT-WEEK: 198748

TITLE: Controlling operation of cooking appts. - computing value corresp. to thermal capacity of food in appts. from detected temp. and elapsed period

PF Publication Date (1):
19871202

PF Publication Date (2):
19900502

PF Publication Date (3):
19890404

Equivalent Abstract Text (4):
The food measuring method includes the steps of heating a quantity of food material to a prescribed set temperature in the cooking apparatus, stopping the heating for a predetermined period for radiating heat from the food material, applying heat to the food material for a prescribed period. The actual temperature of the food material, is detected. A value corresponding to the thermal capacity of the material in the cooking apparatus is computed from the detected temperature and the elapsed time.

Standard Title Terms (1):
CONTROL OPERATE COOK APPARATUS COMPUTATION VALUE CORRESPOND THERMAL CAPACITY FOOD APPARATUS DETECT TEMPERATURE ELAPSED PERIOD

L15: Entry 3 of 5 File: JPAB Jun 28, 1983

PUB-NO: JP358108337A
DOCUMENT-IDENTIFIER: JP 58108337 A
TITLE: HEAT COOKING DEVICE

PUBN-DATE: June 28, 1983

INVENTOR-INFORMATION:

NAME	COUNTRY
ZUSHI, SADAO	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
TOSHIBA CORP	

APPL-NO: JP56208328
APPL-DATE: December 23, 1981

INT-CL (IPC): F24C 1/00; F24C 7/08

ABSTRACT:

PURPOSE: To improve the finishing of food and to stabilize automatic cooking by controlling the heating based on a heating time set in accordance with the weight of the food at a time point whereat the temperature of the food reaches a set temperature in an automatic electronic range.

CONSTITUTION: A specified temperature Tho whereat the effect of the initial temperature of food is gone, and data on relations between the weight of each kind of food 7 and a time required for cooking the same, are stored in a control unit 9. After heat cooking is started, a temperature sensor 6 detects the temperature of heated food 7 and inputs the same in the control unit 9. At the time point whereat the detected temperature reaches the specified temperature Tho, the control unit 9 sets a heating time T in accordance with the weight of the food detected by a weight sensor 8. Heating is stopped when this time T passes away. By this constitution, stable and excellent finishing can be obtained constantly irrespective of the quantity of food and the initial temperature thereof.

L15: Entry 3 of 5 File: JPAB Jun 28, 1983

DOCUMENT-IDENTIFIER: JP 58108337 A
TITLE: HEAT COOKING DEVICE

Abstract Text (2):
CONSTITUTION: A specified temperature Tho whereat the effect of the initial temperature of food is gone, and data on relations between the weight of each kind of food 7 and a time required for cooking the same, are stored in a control unit 9. After heat cooking is started, a temperature sensor 6 detects the temperature of heated food 7 and inputs the same in the control unit 9. At the time point whereat the detected temperature reaches the specified temperature Tho, the control unit 9 sets a heating time T in accordance with the weight of the food detected by a weight sensor 8. Heating is stopped when this time T passes away. By this constitution, stable and excellent finishing can be obtained constantly irrespective of the quantity of food and the initial temperature thereof.

Publication Date (1):
19830628

WEST

Generate Collection | Print

L15: Entry 2 of 5 File: JPAB Feb 26, 1990

PUB-NO: JP402056889A
DOCUMENT-IDENTIFIER: JP 02056889 A
TITLE: HIGH-FREQUENCY GENERATOR FOR MICROWAVE OVEN

PUBN-DATE: February 26, 1990

INVENTOR-INFORMATION:

NAME	COUNTRY
MATSUKURA, TOYOTSUGU	
SAWAE, TAKAO	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
MATSUSHITA ELECTRIC IND CO LTD	

APPL-NO: JP63208711
APPL-DATE: August 23, 1988

US-CL-CURRENT: 219/715
INT-CL (IPC): H05B 6/66

ABSTRACT:

PURPOSE: To uniformly cook the food by making the accumulated quantity of the product of the high-frequency output heating the food and the heating time equal regardless of the commercial power frequency of 50Hz or 60Hz.

CONSTITUTION: A microwave oven is constituted to have the relationship P60=1.2xP50, where P50 is the high-frequency output for 50Hz and P60 is the high-frequency output for 60Hz when the primary voltage of a high-voltage transformer 13 is 100V. A time switch 17 driven by a synchronous type motor 16 as a timing device determining the heating time has the relationship of T50=1.2xT60, where T50 is the limit time for 50Hz and T60 is the limit time for 60Hz, because the rotating speed of the synchronous motor 16 has the proportional relationship to the frequency. The accumulated quantity of the product of the high-frequency output heating the food and the heating time for 50Hz and the accumulated quantity of the product of the high-frequency output heating the food and the heating time for 60Hz are made equal, constant energy is applied to the food regardless of the commercial power frequency of 50Hz or 60Hz, thus the food can be uniformly cooked.

L15: Entry 2 of 5 File: JPAB Feb 26, 1990

DOCUMENT-IDENTIFIER: JP 02056889 A
TITLE: HIGH-FREQUENCY GENERATOR FOR MICROWAVE OVEN

Abstract Text (1):
PURPOSE: To uniformly cook the food by making the accumulated quantity of the product of the high-frequency output heating the food and the heating time equal regardless of the commercial power frequency of 50Hz or 60Hz.

Abstract Text (2):
CONSTITUTION: A microwave oven is constituted to have the relationship $P60=1.2\times P50$, where P50 is the high-frequency output for 50Hz and P60 is the high-frequency output for 60Hz when the primary voltage of a high-voltage transformer 13 is 100V. A time switch 17 driven by a synchronous type motor 16 as a timing device determining the heating time has the relationship of $T50=1.2\times T60$, where T50 is the limit time for 50Hz and T60 is the limit time for 60Hz, because the rotating speed of the synchronous motor 16 has the proportional relationship to the frequency. The accumulated quantity of the product of the high-frequency output heating the food and the heating time for 50Hz and the accumulated quantity of the product of the high-frequency output heating the food and the heating time for 60Hz are made equal, constant energy is applied to the food regardless of the commercial power frequency of 50Hz or 60Hz, thus the food can be uniformly cooked.

Publication Date (1):
19900226

L15: Entry 1 of 5 File: JPAB Nov 10, 1995

PUB-NO: JP407296071A
DOCUMENT-IDENTIFIER: JP 07296071 A
TITLE: MENU MANAGEMENT DEVICE

PUBN-DATE: November 10, 1995

INVENTOR-INFORMATION:

NAME	COUNTRY
MIYAZAKI, TAKESHI	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
FUJITSU F I P KK	

APPL-NO: JP06089288
APPL-DATE: April 27, 1994

INT-CL (IPC): G06 F 17/60

ABSTRACT:

PURPOSE: To realize series of flow concerning the preparation of a scheduled menu, the calculation of component values and the calculation of ordering quantity of food in short time and by correct and simple operation, in a menu management device preparing a menu.

CONSTITUTION: The device is provided with a scheduled menu DB6, a dish changing picture 14, a dish retrieving picture 15 and a processing part 12 taking out the dish of a menu on a change-instructed day, etc., from the scheduled menu DB6 so as to display them on the dish changing picture 14, taking out the list of a dish matching with a retrieving condition by retrieving a dish DB3 in correspondence to the instruction of a dish to change and the input of the retrievzing condition of a dish after change from on he dish changing picture 14 so as to display it on a dish retrieving picture 15, and replacing the change-instructed dish with the dish after change in correspondence to the instruction of the dish after change on the dish retrieving picture 15 so as to store it in the sheduled menu DB6.

L15: Entry 1 of 5 File: JPAB Nov 10, 1995

DOCUMENT-IDENTIFIER: JP 07296071 A
TITLE: MENU MANAGEMENT DEVICE

Abstract Text (1):
PURPOSE: To realize series of flow concerning the preparation of a scheduled menu, the calculation of component values and the calculation of ordering quantity of food in short time and by correct and simple operation, in a menu management device preparing a menu.

Abstract Text (2):
CONSTITUTION: The device is provided with a scheduled menu DB6, a dish changing picture 14, a dish retrieving picture 15 and a processing part 12 taking out the dish of a menu on a change-instructed day, etc., from the scheduled menu DB6 so as to display them on the dish changing picture 14, taking out the list of a dish matching with a retrieving condition by retrieving a dish DB3 in correspondence to the instruction of a dish to change and the input of the retrievzing condition of a dish after change from on he dish changing picture 14 so as to display it on a dish retrieving picture 15, and replacing the change-instructed dish with the dish after change in correspondence to the instruction of the dish after change on the dish retrieving picture 15 so as to store it in the sheduled menu DB6.

Publication Date (1):
19951110

End of Result Set

Generate Collection | Print

L14: Entry 1 of 1 File: JPAB Sep 16, 1994

PUB-NO: JP406259662A
DOCUMENT-IDENTIFIER: JP 06259662 A
TITLE: RECEIPT ISSUE DEVICE

PUBN-DATE: September 16, 1994

INVENTOR-INFORMATION:

NAME	COUNTRY
KIMURA, MASAHIDE	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
OLYMPUS OPTICAL CO LTD	

APPL-NO: JP05046763
APPL-DATE: March 8, 1993

INT-CL (IPC): G07G 1/12; G06F 15/20; G06F 15/21

ABSTRACT:

PURPOSE: To provide the receipt issue device which improves the service for customers by providing a sales cooking input means, a cooking retrieval means, and a receipt print means.

CONSTITUTION: A nutrition calculating part 3 uses a food component table 2 to calculate the nutrition quantity in accordance with food components constituting cooking, and a cooking register part 4 registers the cooking ID, the cooking name, contents, and the nutrition quantity in a cooking table 5. A sales cooking input part 6 is used to input cooking sold to each customer at the time of issuing a receipt, and a subtotal/grand total calculating part 7 uses a cooking table 5 to calculates the amount of money for cooking sold to the customer and the grand total of nutrition quantity. A receipt issue part 8 issues the receipt to show the contents of sold cooking the amount of money, and the nutrition quantity to the customer and prints them on a receipt 9A. Thus, the receipt 9A where required information related to the nutrition quantity based on sold cooking is shown for each customer is issued.

L14: Entry 1 of 1 File: JPAB Sep 16, 1994

DOCUMENT-IDENTIFIER: JP 06259662 A
TITLE: RECEIPT ISSUE DEVICE

Abstract Text (2):
CONSTITUTION: A nutrition calculating part 3 uses a food component table 2 to calculate the nutrition quantity in accordance with food components constituting cooking, and a cooking register part 4 registers the cooking ID, the cooking name, contents, and the nutrition quantity in a cooking table 5. A sales cooking input part 6 is used to input cooking sold to each customer at the time of issuing a receipt, and a subtotal/grand total calculating part 7 uses a cooking table 5 to calculates the amount of money for cooking sold to the customer and the grand total of nutrition quantity. A receipt issue part 8 issues the receipt to show the contents of sold cooking the amount of money, and the nutrition quantity to the customer and prints them on a receipt 9A. Thus, the receipt 9A where required information related to the nutrition quantity based on sold cooking is shown for each customer is issued.

Publication Date (1):
19940916

WEST

End of Result Set

Generate Collection Print

L14: Entry 1 of 1 File: JPAB Sep 16, 1994

PUB-NO: JP406259662A
DOCUMENT-IDENTIFIER: JP 06259662 A
TITLE: RECEIPT ISSUE DEVICE

PUBN-DATE: September 16, 1994

INVENTOR-INFORMATION:

NAME	COUNTRY
KIMURA, MASAHIDE	

ASSIGNEE-INFORMATION:

NAME	COUNTRY
OLYMPUS OPTICAL CO LTD	

APPL-NO: JP05046763
APPL-DATE: March 8, 1993

INT-CL (IPC): G07G 1/12; G06F 15/20; G06F 15/21

ABSTRACT:

PURPOSE: To provide the receipt issue device which improves the service for customers by providing a sales cooking input means, a cooking retrieval means, and a receipt print means.

CONSTITUTION: A nutrition calculating part 3 uses a food component table 2 to calculate the nutrition quantity in accordance with food components constituting cooking, and a cooking register part 4 registers the cooking ID, the cooking name, contents, and the nutrition quantity in a cooking table 5. A sales cooking input part 6 is used to input cooking sold to each customer at the time of issuing a receipt, and a subtotal/grand total calculating part 7 uses a cooking table 5 to calculates the amount of money for cooking sold to the customer and the grand total of nutrition quantity. A receipt issue part 8 issues the receipt to show the contents of sold cooking the amount of money, and the nutrition quantity to the customer and prints them on a receipt 9A. Thus, the receipt 9A where required information related to the nutrition quantity based on sold cooking is shown for each customer is issued.

L5: Entry 1 of 1 File: USPT May 13, 1997

DOCUMENT-IDENTIFIER: US 5630070 A
TITLE: Optimization of manufacturing resource planning

Abstract Text (1):
A method for constrained material requirements planning, optimal resource allocation, and production planning provides for an optimization of a manufacturing process by designating the amounts of various manufactured products to be produced, which products include both end products as well as subassemblies to be employed in the manufacture of one or more of the end products. In order to accomplish the optimization, the method employs an objective function such as the maximization of income in a situation wherein there are limitations on the inventory of raw materials and tools to be employed in the manufacturing process. Data describing elemental steps in the manufacturing process for the production of each end product, as well as the quantity or demand for each end product which is to be supplied, are presented as a set of linear mathematical relationships in matrix form to be inserted in a computer which determines the optimum number of each end product in accordance with an LP optimization algorithm. The matrix contains bill of material data, and various constraints such as a constraint on the sum of products shipped and used as subassemblies, and constraints based on inventory, on available time for use of resources such as tools, and on inventory left over from an early production run for a later run.

US Patent No. (1):
5630070

Brief Summary Text (3):
A need for resource allocation decisions arises in a broad range of technological and industrial areas such as the assignment of transmission facilities in telephone transmission systems, the control of the product mix of a factory, the deployment of industrial equipment, and inventory control, by way of example. Resource allocation in this context means, in general, the deployment of specific technological or industrial resource for the production of particular technological or industrial results.

Brief Summary Text (8):
Presently available MIS is directed primarily to data management systems. Most important manufacturing decisions (for example, what to make, how much to make, when and where to make it) are ultimately made by humans rather than by an MIS. Typically, a manufacturer uses intuition and experience together with knowledge about manufacturing capacity and market demand to determine an initial production plan. Then the manager would run MRP and/or CRP to produce reports describing inconsistencies between a production plan and availability of a resource. This would be followed, possibly, by a revision of the production plan with a rerun of the MRP and the CRP. This is time consuming, and the reports are difficult to interpret for purposes of revising a production plan so as to alleviate a shortage of a particular material employed in the production process. An attempt to run an infeasible production plan can result in missed customer shipments, excess raw material inventory, long cycle times, production bottlenecks, poorly utilized capacity, and idle workers. Even when the production plan is feasible, the manufacturer must deal with the lengthy process of manually revising the production plan until receipt of a report from MRP and CRP indicating no shortages. The process can result in poor

resource allocation decisions, such as the allocation of scarce resources to low profit products.

Brief Summary Text (9):
The limitations of presently available MRP result in a common manufacturing problem which is a shortage of raw material or subassemblies. For example, in the situation wherein a manufacturer has more orders than can be filled, the manufacturer would like to fill the orders in a manner which would maximize the profit, or which would minimize the inventory, or would meet some other goal.

Brief Summary Text (11):
The aforementioned problem is overcome and other advantages are provided by a method which provides for constrained material requirements planning, optimal resource allocation, and production planning. In accordance with the invention, the optimization of a manufacturing process is accomplished by designating the amounts of various manufactured products to be produced, which products include both end products as well as subassemblies to be employed in the manufacture of one or more of the end products, so as to meet an objective function such as the maximization of income in a situation wherein there are limitations on the inventory of raw materials and tools to be employed in the manufacturing process.

Brief Summary Text (13):
It has been the practice to establish a bill of materials (BOM) including materials such as the silicon, the etchants, the photoresists and the dopants which constitute an inventory of materials needed in the manufacturing process. It has also been the practice to establish a bill of resources (BOR) including resources such as the vacuum chambers, the ovens, the steppers, and the slicers which constitute an inventory of resources needed for the manufacturing process. In the event that there is adequate inventory of both materials and resources to provide as much of the end products as may be desired, it has been the practice to employ an MRP to check how much of each material and resource is required for a production run, thereby to insure that there is adequate inventory, and to facilitate reorder of materials and pricing of the end products.

Brief Summary Text (14):
The invention is directed to the situation in which there is insufficient inventory of one or more of the materials, and possibly a lack of the requisite number of one or more of the resources, needed to accomplish the production run. In this situation, the constraints of inventory restrict the manufacturing process such that only a fraction of the desired numbers of the various end products can be produced. This forces the manufacturer to make a decision with respect to allocation of the available material and resources to provide the optimum number of each end product, with the optimization being done in accordance with some objective function. As an example of objective function, a manufacturer frequently selects maximization of income or profit as the basis for optimizing the manufacturing process under the constraint of insufficient inventory. Instead of performing the optimization by heuristic methods, as has been done in the past, the invention provides a method for definitively establishing, in a mathematical sense, the necessary amount of each of the end products to be produced to meet the objective function in the presence of the inventory constraints.

Brief Summary Text (16):
In accordance with a feature of the invention, the matrix contains: (1) BOM data in the situation wherein a lack of material inventory provides a constraint, (2) a statement in the form of a constraint for each end product that the sum of the quantity of an end product supplied plus the quantity of the end product employed as a subassembly cannot exceed the quantity of the end product which may be available from inventory plus the quantity produced in the manufacturing process, (3) a statement in the form of a constraint for each product, including subassemblies, that the quantity of a product supplied cannot exceed the quantity of the product which may be available from inventory plus the quantity produced in the manufacturing process, (4) a statement in the form of a constraint for each product that the quantity of a product to be shipped cannot exceed the quantity which is desired, and (5) production of each product and shipment of each product cannot be less than zero. This matrix is referred to as the A matrix. Also, on the right hand

side of the A matrix is a vector, referred to as the b vector, containing data as to the amount of items, both end products and raw materials, in inventory plus the demand for each end product. The foregoing contents of the A matrix and the b vector reflect a simple situation wherein there are adequate resources so that there is no resource constraint. In the case wherein a lack of resources imposes a constraint, then there are additional statements including BOR data and constraints in the use of the resources, such as the amount of time available for use of a resource.

Drawing Description Text (3):
FIG. 1 shows a simplified diagram of a manufacturing process producing semiconductor circuit products wherein a choice of the quantities of the various end products, based on constrains of available inventory of raw materials and available manufacturing tools, is to be made based on the procedures of the invention;

Detailed Description Text (6):
The operation of the invention will be explained hereinafter by a mathematical description. However, in order to facilitate explanation of the invention, a manufacturing operation simpler than that of the foregoing semiconductor circuit fabrication will be presented. Accordingly, the ensuing description makes reference to a restaurant producing various forms of omelets and sandwiches from a limited inventory of raw ingredients consisting of peppers, mushrooms, butter, eggs, ham, cheese and bread. Also included in the inventory, by way of example, are a few plain sandwiches each of which consists of two slices of bread, and a single previously prepared cheese sandwich. The quantities of the various ingredients and the selling prices of the various products are presented in the following description. In order to make an analogy between the production of omelets and sandwiches with the foregoing manufacture of semiconductor circuits, it will be assumed that a plain omelet can be served directly to a customer, or that the plain omelet can serve as a subassembly in the production, or manufacture, of a more complex omelet, such as a cheese omelet wherein further preparation cooking time is employed to incorporate the cheese. Similar comments apply to other more complex types of omelets and to the various forms of sandwiches as will be described.

Detailed Description Text (7):
Upon completion of the description of the preparation of the various omelets and the sandwiches, the description continues with the arrangement of the various raw materials plus inventory constraints, and other constraints of the invention, within a matrix format for insertion into a computer to perform LP optimization. The optimization attains the numbers, or quantities of the various omelets and sandwiches which meet an objective function, herein in this example, a maximization of income to the restaurant. Further examples are given to demonstrate constraints due to lack of a sufficient number of restaurant tools such as toasters and skillets, and also to demonstrate the procedure of the invention for the situation wherein the preparation of the food extends over two intervals of time, such as early and late lunch, wherein there may be a delivery of raw ingredients after the early lunch to supplement the inventory left over from the early lunch. This is then followed by the mathematical description.

Detailed Description Text (9):
For example, Table 2 shows that the customers have ordered six of the vegetable omelets. Accordingly, the foregoing quantities of each of the four ingredients of the vegetable omelet would be multiplied by six to obtain the total amount of raw materials employed in meeting the customer demand for vegetable omelet. Similar calculations would be employed for each of the other food products, and the results are to be summed together to give a grand total of the quantities of the raw materials of all the demanded food products. In the event that the restaurant has a cheese sandwich left over from a previous production run, which sandwich is to be used to meet the present customer demand, then the total amount of raw materials required for the present production run can be reduced by the amount in the left-over cheese sandwich. Similarly, if there were left-over plain sandwiches (just two slices of bread per sandwich), the amount of bread required to meet the customer demand would be reduced by the amount of bread in the plain sandwiches. Table 3 lists the inventory available to the cook at the beginning of the production run. As will be seen in the following example, there is an insufficiency, or shortage, for each ingredient except for mushrooms wherein there is an excess, as indicated in

Table 5. Note that, in Table 5, the amount of the shortage of mushrooms is shown as zero to avoid the appearance of negative amounts in the ensuing mathematical explanation. The example of the restaurant is as follows.

Detailed Description Text (12):
Table 2 gives demand, Table 3 gives inventory. Note that the cook has some finished goods inventory (1 cheese sandwich) and some subassembly inventory (3 plain sandwiches). Table 4 gives the total requirements for the raw ingredients (subassembly and finished goods stock are netted). Table 5 gives the net requirements for the raw ingredients. The information in Table 5 is the usual output of MRP. It tells the manufacturer what additional materials are required in order to meet the end product demand.

Detailed Description Text (26):
Equation set (1) has nine lines corresponding to the nine constraints. The variables to the left of the inequality sign are arranged so that variables representing the same food product in a plurality of the lines appear in the same column. The column of variables to the right of the inequality signs are recognized as being the inventory of Table 3. The first seven lines relate to the seven raw food ingredients of the inventory, and the last two lines relate to the two subassemblies (plain omelet and plain sandwich) of the inventory. In the first ten columns of variables from the left, each column represents a specific one of the food products to be manufactured as listed in Table 1. Also, the first seven row elements of each column, presents the ingredients, exclusive of any required subassembly, for producing the food product. The coefficient for each variable designates the quantity of the food product to be employed in accordance with the recipes of Table 1. The first column of variables at the left side of the equation set discloses, in its first seven row elements, the amount of eggs and butter to be employed in making a single plain omelet. The second column of variables from the left discloses, in its first seven row elements, the amount of cheese to produce a single cheese omelet. In similar fashion, the remaining ones of the first ten columns from the left, in their respective first seven row elements, disclose ingredients for the remaining food products of Table 1.

Detailed Description Text (27):
The eighth row of equation set (1) deals with the constraint that the sum of all plain sandwiches employed in subassemblies minus the amount of plain sandwiches produced must not exceed inventory. The ninth row, which includes an entry (to be described hereinafter) in the eleventh column from the left, deals with the constraint that the sum of all plain omelets employed in subassemblies plus the amount of plain omelets eaten directly minus the amount of plain omelets produced must not exceed inventory.

Detailed Description Text (42):
The material availability constraints for subassemblies that have demand (e.g., plain omelet) are altered to reflect the facts that the sum of the quantity that is served, plus the quantities that are used in other products, cannot exceed the quantity that is available from production and inventory. Thus the final equation of (1) is given by

Detailed Description Text (43):
For each of the end products, we add constraints that say that the amount of the produced served cannot exceed the amount of the product available from production and inventory.

Detailed Description Text (64):
Notice that this solution is feasible with respect to the inventory availability. That is, if we apply standard MRP logic to the shipment vector s, treating it as a demand, no material shortages result.

Detailed Description Text (65):
In this particular case, translating the LP solution in to an actual production plan is quite easy. A total of 12 plain omelets are made; 4 are used for cheese omelets, 1 is used for a ham omelet, 2 are used for ham and cheese omelets and 5 are used for vegetable omelets, all of which are served. No plain omelets are served. The cheese

sandwich from inventory is served. A total of 10 plain sandwiches are made. These, together with the three plain sandwiches in inventory are used to make 1 cheese sandwich, 3 ham sandwiches, 5 ham and cheese sandwiches, and 4 ham and egg sandwiches, all of which are served.

Detailed Description Text (66):
Note that a total of 40 eggs are used (36 in omelets, and 4 in egg and ham sandwiches), 30 ounces of ham are used, 20 slices of bread plus 3 plain sandwiches are used, and 10 green peppers are used. There is no remaining inventory of these items. A total of 10 ounces of mushrooms are used, so 4 ounces remain, 12 teaspoons of butter are used, so 3 teaspoons remain, and 27 ounces of cheese are used, so 3 ounces remain. This combination of omelets and sandwiches can be made from the available inventory; furthermore no additional omelets or sandwiches can be made from the remaining inventory. The value of this allocation of resources is $75. There is no other combination of omelets and sandwiches which can be made from the available inventory and has a value higher than $75.

Detailed Description Text (67):
In the foregoing example in the preparation of omelets and sandwiches, constraints were placed on inventory of food materials. The example is now extended to include a bill of resources wherein constraints are present also on availability of equipment used in preparation of the food products. Therefore, in addition to the materials (e.g., food) we now also consider the availability of two resources, skillets and a toaster.

Detailed Description Text (81):
Extending the single period model to a multi-period model requires additional decision variables and constraints. These variables and constraints are used to keep track of the inventory (raw materials, subassemblies, and products) and the demand backlog that is carried from one period to the next.

Detailed Description Text (96):
Let v.sub.6 =number of plain sandwiches held in inventory at the end of the early lunch period.

Detailed Description Text (97):
Let v.sub.7 =number of cheese sandwiches held in inventory at the end of the early lunch period

Detailed Description Text (98):
Let v.sub.8 =number of ham sandwiches held in inventory at the end of the early lunch period

Detailed Description Text (99):
Let v.sub.9 =number of ham and cheese sandwiches held in inventory at the end of the early lunch period

Detailed Description Text (100):
Let v.sub.10 =number of ham and egg sandwiches held in inventory at the end of the early lunch period

Detailed Description Text (101):
v.sub.11 =number of slices of bread held in inventory at the end of early lunch period

Detailed Description Text (102):
v.sub.12 =amount of cheese held in inventory at the end of early lunch period

Detailed Description Text (103):
v.sub.13 =amount of ham held in inventory at the end of early lunch period

Detailed Description Text (104):
v.sub.14 =amount of eggs held in inventory at the end of early lunch period

Detailed Description Text (115):

Notice that in the single period model the resource and material availability constraints were inequalities. In the multi-period model, it is necessary to track the carry-over of inventory from one period to the next. Inventory carried from one period to the next is exactly equal to the amount of material that was available at the beginning of the period, minus what is used during the period.

Detailed Description Text (117):
Notice that in the material balance constants for the second period, the supply remaining at the end of the first period is included as additional material availability. Also, in this case, since there are only two periods, we do not require additional variables to track the inventory available at the end of the late period, and the material availability constraints are inequalities. We also include constraints on the inventory variables that specify that inventory must be non-negative.

Detailed Description Text (142):
This concept of carrying inventory and backlog from one period into the next period can be extended to models with arbitrarily many periods.

Detailed Description Text (143):
The objective function of the linear program can include any additional terms that are linear combinations of the model variables. For example, it can include a term representing the manufacturing cost of each of the products as a multiple of the appropriate production variables x, backlog cost, as multiples of the backlog variables b, holding costs, as multiples of the inventory variables v, etc.

Detailed Description Text (149):
Require v.sub.jt for part number j if excess inventory of p/n j can be carried over from period t to period t+1.

Detailed Description Text (151):
Require v.sub.j,t for part number j if excess inventory of p/n j can be scrapped at end of period t.

Detailed Description Text (157):
b.sub.d,t for each demand d and each period t such that ##EQU10## 7. Define inventory balance constraints and right hand side. ##EQU11## for all parts j and all periods t-1. Here ##EQU12## is the total shipment of part number j in period t, to all of the demands d for this part number {d.epsilon.D.vertline.p(d)=j}.

Detailed Description Text (177):
H.sub.j,t is the holding cost, or inventory carrying cost for p/n j in period t.

Detailed Description Text (190):
Since both the inventory balance equations and the profit maximization objective function are linear (see formulation below), it is not surprising or new to consider linear programming approaches to resource allocation problems. Several "textbook" formulations have been published. However, the inventory management literature cautions against the use of linear programming for resource planning because of the difficulty of accurately formulating the allocation problem for a multi-level assembly process, because of the size and complexity of the formulation for even simple single level assembly processes, and because of the difficulty of interpreting and implementing the solution of the linear program. Recent improvements in LP software packages and computing hardware have rendered the size considerations less forbidding; it is now possible to solve realistic problems in a reasonable amount of time. For example, on an RS/6000, the LP corresponding to a real production planning problem for 400 part numbers, 500 demands, and 26 weeks, can be solved in under 10 minutes cpu time. This invention addresses the remaining considerations: accurately formulating the allocation problem, and enabling effective use of the results by inventory managers.

Detailed Description Text (242):
Similarly, the inventory balance constraints can be modified to consider the time-sensitive part or resource usage resulting from engineering and/or technology changes.

Detailed Description Text (248):
Additional manufacturing considerations, such as yield and fallout can easily be incorporated into the inventory balance constraints. We let .alpha..sub.j be the manufacturing yield of p/n j. That is, for each unit of p/n j that is useable for shipment or for use in other products, 1/.alpha..sub.j units of p/n j must be produced. If .alpha..sub.j =1, then every unit of p/n j is useable. If .alpha..sub.j =0.75 then three quarters of the units of p/n j produced are useable.

Detailed Description Text (335):
In general, the number of possible combinations of releases for any specified demand set grows rapidly as the number of chip types, number of wafers, or number of wafers per chip increases. Excess chip inventory costs, and/or wafer product cost data can be used to select among identified wafer release combinations. Alternatively, we can formulate a linear (integer) program which will identify the optimal release combination. The formulation can be expanded to take into account existing inventory of product, chips, and wafers and other resource constraints.

Detailed Description Text (350):
1. Extract data (Demand, inventory, Bill-of Materials, Bill-of-Resources, Resonance availability cost and revenue data) from site

Detailed Description Text (351):
information systems. Source of each data element will be determined by the particular configuration of information systems. In the diagram, the demand data, bill-of-material data, and inventory data are extracted from the Material Requirements Planning System, the bill-of resource data and the resource availability data are extracted from the Capacity Requirements Planning system, and the cost and revenue data is extracted from a third manufacturing information system.

Detailed Description Text (356):
2. Inventory data: can include on-hand inventory, supplier orders, planned supplier orders, contractual limits.

Detailed Description Text (364):
The demand data, inventory data, and resource availability data are used in the construction of the right-hand-side of the constraints.

Detailed Description Text (367):
Specifically, in Step 1, demand data, bill-of-material data, inventory data, and cost and revenue data are extracted from an MRP system or from an other manufacturing information system. In Step 2, the Optimal Resource Allocation Procedure processes this data, formulates the Linear Program, invokes an LP solver, extracts the optimal values of the LP variables, translates these values in to a shipment schedule and a production schedule. Then, in Step 3, the shipment schedule and the production schedule are inserted into the MRP system or other manufacturing information system.

Detailed Description Text (371):
Specifically, in Step 1, demand data, bill-of-material data, and inventory data are extracted from an MRP system or other manufacturing information system, fill-of-resource data and resource availability data are extracted from a CRP system or other manufacturing information system, and cost and revenue data is extracted from the MRP system, the CRP system, or some other manufacturing information system. In Step 2, the Optimal Resource Allocation Procedure processes this data, formulates the Linear Program, invokes an LP solver, extracts the optimal values of the LP variables, translates these values in to a shipment schedule and a production schedule. Then, in Step 3, the shipment schedule and the production schedule are inserted into the MRP system, the CRP system or the other manufacturing information system.

Detailed Description Text (375):
Specifically, in Step 1, demand data, bill-of-material data, inventory data, and cost and revenue data are extracted from an MRP system. In a subsequent step (Step

1a) the bill-of-material data is processed to eliminate from each bill-of materials all raw material part numbers which are not in the pre-specified set of critical parts, and all product part numbers which do not use, either directly or on subassemblies, raw materials in the pre-specified set of critical parts. A resulting "stripped" bill-of materials may have no component parts. Inventory data for raw material part numbers which are not on the pre-specified critical parts list and have demand are replaced by the total demand for that part number in each time period. In Step 2, the Optimal Resource Allocation Procedure processes the reduced set of data produced by Step 1a and formulates the Linear Program corresponding to the reduced set of data. A product which has no component parts on its bill-of-materials results in production variables which are unconstrained, that s, they can take arbitrarily large values. The shipment variables corresponding to these products will exactly equal demand. Step 2 then invokes an LP solver, extracts the optimal values of the LP variables, translates these values in to a shipment schedule and a production schedule. Then, in Step 3, the shipment schedule and the production schedule are inserted into the MRP system. The MRP then uses the original set of bill-of-materials data, the shipment schedule, and the production schedule to determine the requirements of all of the part numbers. In an alternate implementation of this method, the bill-of-material pre-processing (Step 1a) is omitted. Subsequent to Step 1 in Step 1b the inventory data for every raw-material not on the per-specified critical component list, the inventory data is replaced by the vector (M,M,M, . . . ,M) where M is some very large quantity (e.g., expected total annual part usage). This results in that part usage constraints for these parts having extremely large right-hand-sides. In effect, the constraint has been omitted from the formulation. Decision variables that appear only in these constraints become unconstrained.

Detailed Description Text (377):
Specifically, in Step 1, demand data, bill-of-material data, and inventory data are extracted from an MRP system or other manufacturing information system, bill-of-resource data and resource availability data are extracted from a CRP system or other manufacturing information system, and cost and revenue data is extracted from the MRP system, the CRP system, or some other manufacturing information system. The inventory data is extracted as follows: the inventory of part number i in period to is given by (1) the on hand stock of i for period t=1, (2) the amount of i already ordered and scheduled to arrive in period t for 1leadtime (i) In Step 2, the Optimal Resource Allocation procedure processes this data, formulates the Linear Program, invokes an LP solver, extracts the optimal values of the LP variables, translates these values in to a shipment schedule a production schedule, and a material usage schedule. Then, in Step 3, the shipment schedule the schedule, and a material usage schedule are inserted into the MRP system, the CRP system or the other manufacturing information system. If available the MRP system is used to further analyze and report on the usage of materials, particularly on the usage of material beyond its leadtime. Then, either the material usage schedule together with the on-hand and on-order inventory data, or the results of the further MRP analysis, are used to generate new orders for each part number (outside of its leadtime).

Detailed Description Text (379):
Specifically, in Step 1, demand data, bill-of-material data, and inventory data are extracted from an MRP system or other manufacturing information, bill-of-resource data and resource availability data are extracted from a CRP system or other manufacturing information system, and cost and revenue data is extracted from the MRP system, the CRP system, or some other manufacturing information system. The demand data includes previously accepted orders, the specified new order, and a forecast of future orders. Each order is classified according to its type. The due date for the new order is set to the current date, and it is given a high revenue value-higher than the total value of the forecasted orders. In Step 2, the Optimal Resource Allocation Procedure processes this data and formulates the Linear Program. This LP includes shipment bounds, reflecting the fact that the previously committed orders must be shipped on their respective due dates. Then the LP solver is invoked, and the optimal values of the LP variables are extracted and translated in to a shipment schedule and a production schedule. The date at which the new order ships is the earliest possible date at which this order can be shipped. This date is reported to the user, or returned to the MRP system or other manufacturing information system.

Detailed Description Text (381):
Specifically, in Step 1, demand data, bill-of-material data, and inventory data are extracted from an MRP system or other manufacturing information system, bill-of-resource data and resource availability data are extracted from a CRP system or other manufacturing information system, and cost and revenue data is extracted from the MRP system, the CRP system, or some other manufacturing information system. The demand data includes previously accepted orders, the specified new order, and a forecast of future orders. Each order is classified according to its type. Revenue data for forecasted orders is scaled by the probability of the order materializing. The due date for the new order is set to the current date. In Step 2, the Optimal Resource Allocation procedure processes this data and formulates the Linear Program. This LP includes shipment bounds, reflecting the fact that the previously committed orders must be shipped on their respective due dates. Then the LP solver is invoked, and the optimal values of the LP variables are extracted and translated in to a shipment schedule and a production schedule. If the new order does not appear on the shipment schedule, then it is not profitable to make the order and it should be rejected, or the customer's price should be increased so that the order becomes profitable. If the new order does appear on the shipment schedule, then the date at which the new order ships is the most profitable date at which this order can be shipped. If earlier shipment is desired, the customer price can be increased. The shipment status of the new order, and, if appropriate, the shipment date date are reported to the user, or returned to the MRP system or other manufacturing information system.

Detailed Description Text (391):
Specifically, in Step 1, demand data, bill-of-material data, inventory data, and cost and revenue data are extracted from an MRP system or from an other manufacturing information system. The new BOM is represented as a substitute for the old BOM, with the earliest field for substitute are giving the earliest potential EC execution date. Firm coverage (on-hand plus on-order) is used for parts that will be obsoleted by the EC, and planned coverage, or a usage upper bound is used for the remaining parts. A penalty cost is assigned to the use of the substitute (new level) and/or to scrapping of the obsoleted parts. In Step 2, the Optimal Resource Allocation Procedure processes this data, formulates the Linear Program, invokes an LP solver, extracts the optimal values of the LP variables, translates these values in to a shipment schedule and a production schedule. The solution will give production schedule for each EC level, which can be used to determine the EC break-in date. Then, in Step 3, the shipment schedule and the production schedule and the EC break-in date information are inserted into the MRP system or other manufacturing information system.

Detailed Description Text (393):
Specifically, in Step 1, demand data, bill-of-material data, and inventory data are extracted from an MRP system or other manufacturing information system, bill-of-resource data and resource availability data are extracted from a CRP system or other manufacturing information system, and cost and revenue data is extracted from the MRP system, the CRP system, or some other manufacturing information system. In Step 2, the Optimal Resource Allocation Procedure processes this data, formulates the Linear Program, invokes an LP solver, extracts the optimal values of the LP variables, translates these values in to a shipment schedule and a production schedule. In addition, the "dual variable" are also extracted from the LP solver, and those corresponding to material availability constraints and capacity availability constraints are sorted in decreasing order. Among this set, the constraint with the largest dual variable corresponds to a capacity or material, and a time period such that obtaining more of that capacity or resource in that time period will have the greatest impact on total profit. A list of pairs (material or resource, time period) that have the most potential for impacting profit are reported.

Detailed Description Text (394):
15. A method for End-of-Life Inventory Optimization which determines the optimal allocation of on-hand materials and capacities to products so as to minimize the value of the remaining inventory.

Detailed Description Text (395):
Specifically, in Step 1, demand data, bill-of-material data, and inventory data are extracted from MRP system or other manufacturing information system, bill-of-resource data and resource availability data are extracted from a CRP system or other manufacturing information system, and cost and revenue data is extracted from the MRP system, the CRP system, or some other manufacturing information system. Inventory data is extracted for on-hand and firm order inventory only. The demand data is adjusted, if necessary, to reflect potential demand for each of the possible end products. The holding cost of each material in the final period is set to the value of that material; all other cost and revenue data is eliminated. In Step 2, the Optimal Resource Allocation Procedure processes this data and formulates the Linear Program. The then LP solver is invoked, and the optimal values of the Lp variables are extracted and translated into a shipment schedule and a production schedule. Since the only coefficients in the objective function are holding costs for inventory in the final period, production and shipment schedule correspond to an allocation of resources that minimizes the value of the final inventory.

Detailed Description Text (397):
Specifically, in Step 1, data describing the demand, inventory, bill-of-materials, bill-of-resources, capacity availability, cost and revenue, and bill-of-products is extracted from MRP, CRP and other manufacturing information systems. There may be multiple bill-of-materials and/or multiple bill-of-resources for each product; each bill-of-materials and bill-of-resources may have a distinct cost associated with it. This cost data is included in the cost and revenue data. In Step 2, the Optimal Resource Allocation Procedure processes this data and formulates the Linear Program. There are multiple production variables for each product, corresponding to each of the possible bill-of-materials and bill-of-resources associated with that product. Then the LP solver is invoked, and the optimal values of the LP variables are extracted and translated into a shipment schedule and a production schedule. The production schedule specifies the quantity of each product built with each bill-of-materials and each bill-of-resources in each time period. In Step 3, the shipment schedule and the production schedule are inserted to the MRP system, the CRP system, and the other manufacturing information system.

Detailed Description Text (399):
Specifically, in Step 1, data describing the demand, inventory, bill-of-materials, bill-of-resources, capacity availability, cost and revenue, and bill-of-products is extracted from MRP, CRP and other manufacturing information systems. In Step 2, the Optimal Resource Allocation Procedure processes this data and formulates the Linear Program. Then the LP solver is invoked, and the optimal values of the LP variables are extracted and translated into a shipment schedule and a production schedule. In Step 3, the shipment schedule and the production schedule are inserted in to the MRP system, the CRP system, and the other manufacturing information system.

Detailed Description Paragraph Table (3):
TABLE 3 ____ Inventory
____ Plain sandwich 3 Green pepper 10 oz. Mushroom 14 oz. Butter 15 oz. Eggs 40 Ham 30 oz. Cheese 30 oz. Bread 20 slices Cheese sandwich 1 ____

Detailed Description Paragraph Table (5):
TABLE 5 ____ Net Requirements (shortages)
____ Green pepper 2 oz. Mushrooms 0 (excess inventory) Butter 4 tsp. Eggs 21 Ham 12 oz. Cheese 5 oz. Bread 4 slices
____

Detailed Description Paragraph Table (8):
____ Initial Inventory New Supply
____ Plain sandwiches 2 0 Cheese sandwiches 1 0 Bread 20 slices 30 slices Ham 25 oz. 15 oz. Cheese 30 oz. 20 oz. Eggs 5 2
____

CLAIMS:

1. A method for optimizing component allocation in a manufacture of a plurality of

products of different types from a set of components by a plurality of manufacturing procedures to obtain an optimum production quantity for each of said product types, comprising steps of:

within each of said procedures, establishing quantities of components to be employed in respective ones of said procedures;

providing an inventory of said components, and placing each type of component of the inventory in a separate location of a vector;

arranging said products as variables in respective product columns of a matrix having rows and columns wherein individual ones of the rows are reserved for respective components of the products, there being a plurality of product columns with a separate column for each product type;

establishing a material constraint for the set of components of the respective component rows by, in each of the component rows, multiplying the product variable of each column by coefficients designating the amount of each component in the product, each of the component rows corresponding to the location of an amount of component type in the vector;

via a plurality of production constraints for said products, constraining shipments of respective ones of said product types minus the quantity of each of the respective product types produced to be less than or equal to a quantity of each of the product types in inventory;

placing said production constraints of said product types in respective ones of additional rows of the matrix with shipments being located in separate shipment columns of the matrix and said product types being located in the respective product columns, there being a separate row for each product type having a nonzero shipment, the quantities of the product types in inventory being entered at locations of said vector corresponding to the matrix row having the production constraints;

via a plurality of demand constraints for said products, constraining shipments of respective ones of said product types to be less than or equal to a demand for the respective product types;

placing said demand constraints of said products in separate additional rows of said matrix with shipments being located in respective ones of said shipment columns of the matrix, the demands for said product types being located in separate locations of said vector corresponding to the respective rows of the demand constraints;

applying a linear programming optimization to said matrix and said vector in accordance with an objective function to obtain an optimum production quantity for each of said product types; and

producing, via said plurality of manufacturing procedures, said optimum production quantity for each of said product types.

3. A method according to claim 1 wherein, in said manufacturing procedures, an individual product of a selected type of said products serves as a subassembly to be combined with at least one of said components for fabricating a further one of said products, at least a portion of the total quantity of said selected product type being employed as a subassembly for one or more of said prducts, said method further comprising a step of,

via a set of sum constraints for each of respective types of said products employed as a subassembly in one or more of said products for which there is demand, constraining the total quantity of said selected product type minus a quantity of the selected product type which is produced to be less than or equal to the quantity of said selected product type in inventory.

14. A method according to claim 1 wherein individual ones of said manufacturing procedures can be accomplished by use of substitute components in addition to said first-mentioned components, which are normally used, and wherein:

said step of providing inventory includes a placing of substitute components in said vector;

said step of arranging products includes establishment of additional rows for the substitute components and additional columns for products formed of substitute components; and

said step of establishing a material constraint is repeated for the substitute components.

18. A method according to claim 1 wherein there is set of bounds having at least one bound on a manufacturing parameter, the manufacturing parameter including any one of product production quantity, or product shipping quantity, or inventory stock, the bound being either an upper limit or a lower limit, the method further comprising:

introducing said bounds as bound constraints in the manufacture of the products; and

placing said bound constraints in separate rows of said matrix wherein the magnitude of the bound is placed in a corresponding location of said vector.

19. A method for optimizing resource allocation in a manufacture of a plurality of products of different types from a set of components by use of a plurality of resources in a plurality of manufacturing procedures to obtain an optimum production quantity for each of said product types, comprising steps of:

within each of said procedures, establishing quantities of resources to be employed in respective ones of said procedures;

providing an inventory of said resources, and placing each type of resource of the inventory in a separate location of a vector;

arranging said products as variables in respective product columns of a matrix having rows and columns wherein individual ones of the rows are reserved for respective resources employed in the manufacture of the respective products, there being a plurality of product columns with a separate column for each product type;

establishing a resource constraint for the set of resources of the respective resource rows by, in each of the resource rows, multiplying the product variable of each column by coefficients designating the amount of each resource to be employed in manufacture of the product, each of the resource rows corresponding to the location of an amount of resource type in the vector;

via a plurality of production constraints for said products, constraining shipments of respective ones of said product types minus the quantity of each of the respective product types produced to be less than or equal to a quantity of each of the product types in inventory;

placing said production constraints of said product types in respective ones of additional rows of the matrix with shipments being located in separate shipment columns of the matrix and said product types being located in the respective product columns, there being a separate row for each product type having a nonzero shipment, the quantities of the product types in inventory being entered at locations of said vector corresponding to the matrix row having the production constraints;

via a plurality of demand constraints for said products, constraining shipments of respective ones of said product types to be less than or equal to a demand for the respective product types;

placing said demand constraints of said products in separate additional rows of said matrix with shipments being located in respective ones of said shipment columns of the matrix, the demands for said product types being located in separate locations of said vector corresponding to the respective rows of the demand constraints;

applying a linear programming optimization to said matrix and said vector in accordance with an objective function to obtain an optimum production quantity for each of said product types; and

producing, via said plurality of manufacturing procedures, said optimum production quantity for each of said product types.

21. A method for material constrained production planning whereby a feasible allocation of material to demand for maximization of profit is determined to obtain an optimum production quantity for each of said product types, the material including components in a plurality of manufacturing procedures conducted in accordance with a manufacturing information system for said optimum production quantity, the method comprising steps of:

providing demand data, bill-of-material data, inventory data, cost and revenue data;

within each of said procedures, establishing quantities of components to be employed in respective ones of said procedures;

providing an inventory of said components from said data, and placing each type of component of the inventory in a separate location of a vector;

arranging said products as variables in respective product columns of a matrix having rows and columns wherein individual ones of the rows are reserved for respective components of the products, there being a plurality of product columns with a separate column for each product type;

establishing a material constraint for the set of components of the respective component rows by, in each of the component rows, multiplying the product variable of each column by coefficients designating the amount of each component in the product, each of the component rows corresponding to the location of an amount of component type in the vector;

via a plurality of production constraints for said products, constraining shipments of respective ones of said product types minus the quantity of each of the respective product types produced to be less than or equal to a quantity of each of the product types in inventory;

placing said production constraints of said product types in respective ones of additional rows of the matrix with shipments being located in separate shipment columns of the matrix and said product types being located in the respective product columns, there being a separate row for each product type having a nonzero shipment, the quantities of the product types in inventory being entered at locations of said vector corresponding to the matrix row having the production constraints;

via a plurality of demand constraints for said products, constraining shipments of respective ones of said product types to be less than or equal to a demand for the respective product types;

placing said demand constraints of said products in separate additional rows of said matrix with shipments being located in respective ones of said shipment columns of the matrix, the demands for said product types being located in separate locations of said vector corresponding to the respective rows of the demand constraints;

applying a linear programming optimization to said matrix and said vector in accordance with an objective function to obtain said optimum production quantity for each of said product types to maximize profit;

providing a shipment schedule and a production schedule; and

inserting the shipment schedule and the production schedule into said manufacturing information system for a manufacture of each of said product types in said optimum production quantity.

22. A method for material constrained production planning whereby a feasible allocation of material to demand for maximization of profit is determined to obtain an optimum production quantity for each of said product types, the material including components in a plurality of manufacturing procedures conducted in accordance with a manufacturing information system for said optimum production quantity, the method comprising steps of:

providing demand data, bill-of-resource data, resource availability data, cost and revenue data;

within each of said procedures, establishing quantities of components to be employed in respective ones of said procedures;

providing an inventory of said components from said data, and placing each type of component of the inventory in a separate location of a vector;

arranging said products as variables in respective product columns of a matrix having rows and columns wherein individual ones of the rows are reserved for respective components of the products, there being a plurality of product columns with a separate column for each product type;

establishing a material constraint for the set of components of the respective component rows by, in each of the component rows, multiplying the product variable of each column by coefficients designating the amount of each component in the product, each of the component rows corresponding to the location of an amount of component type in the vector;

via a plurality of production constraints for said products, constraining shipments of respective ones of said product types minus the quantity of each of the respective product types produced to be less than or equal to a quantity of each of the product types in inventory;

placing said production constraints of said product types in respective ones of additional rows of the matrix with shipments being located in separate shipment columns of the matrix and said product types being located in the respective product columns, there being a separate row for each product type having a nonzero shipment, the quantities of the product types in inventory being entered at locations of said vector corresponding to the matrix row having the production constraints;

via a plurality of demand constraints for said products, constraining shipments of respective ones of said product types to be less than or equal to a demand for the respective product types;

placing said demand constraints of said products in separate additional rows of said matrix with shipments being located in respective ones of said shipment columns of the matrix, the demands for said product types being located in separate locations of said vector corresponding to the respective rows of the demand constraints;

wherein said manufacture is accomplished with the use of a set of resources, each resource of said set of resources being available for a predetermined amount of time, the method further comprising

establishing additional resource-constraint rows in said matrix and corresponding additional resource-constraint locations in said vector;

for each of the products employing, in its manufacture, one of said resources, totaling the usage time for each product of said one resource, and setting forth a relationship in the matrix row of said one resource providing for said totaling of resource usage time, said totaling of resource usage time being less than or equal to a maximum amount of resource usage time set forth in the corresponding resource constraint location of said vector;

applying a linear programming optimization to said matrix and said vector in accordance with an objective function to obtain said optimum production quantity for each of said product types to maximize profit;

providing a shipment schedule and a production schedule; and

inserting the shipment schedule and the production schedule into said manufacturing information system for a manufacture of each of said product types in said optimum production quantity.

23. A method for critical components constrained materials requirements planning whereby a specified set of critical raw materials are allocated to demands to obtain an optimum production quantity for each of said product types so as to maximize profit, and the resulting production plan is then analyzed to determine the requirements of all materials not in the specified set, the critical raw materials including components in a plurality of manufacturing procedures conducted in accordance with a manufacturing information system for said optimum production quantity, the method comprising steps of:

extracting demand data, bill-of-material data, inventory data from a manufacturing information system;

eliminating from each bill-of-materials all raw material part numbered units which are not in a predetermined set of critical parts, and all product part numbered units which do not use, either directly or on subassemblies, raw materials in the predetermined set of critical part, thereby to provide a reduced bill of materials;

replacing inventory data for raw material part numbered units which are not on the predetermined critical parts list and which have demand by a total demand for respective ones of the part numbered items in each of a plurality of time periods;

within each of said procedures, establishing quantities of components to be employed in respective ones of said procedures;

providing an inventory of said components, and placing each type of component of the inventory in a separate location of a vector;

arranging said products as variables in respective product columns of a matrix having rows and columns wherein individual ones of the rows are reserved for respective components of the products, there being a plurality of product columns with a separate column for each product type;

establishing a material constraint for the set of components of the respective component rows by, in each of the component rows, multiplying the product variable of each column by coefficients designating the amount of each component in the product, each of the component rows corresponding to the location of an amount of component type in the vector;

via a plurality of production constraints for said products, constraining shipments of respective ones of said product types minus the quantity of each of the respective product types produced to be less than or equal to a quantity of each of the product types in inventory;

placing said production constraints of said product types in respective ones of additional rows of the matrix with shipments being located in separate shipment columns of the matrix and said product types being located in the respective product columns, there being a separate row for each product type having a nonzero shipment, the quantities of the product types in inventory being entered at locations of said vector corresponding to the matrix row having the production constraints;

via a plurality of demand constraints for said products, constraining shipments of respective ones of said product types to be less than or equal to a demand for the respective product types;

placing said demand constraints of said products in separate additional rows of said matrix with shipments being located in respective ones of said shipment columns of the matrix, the demands for said product types being located in separate locations of said vector corresponding to the respective rows of the demand constraints; and

applying a linear programming optimization to said matrix and said vector in accordance with an objective function to obtain said optimum production quantity for each of said product types to maximize profit;

providing a shipment schedule and a production schedule; and

inserting the shipment schedule and the production schedule into said manufacturing information system for a manufacture of each of said product types in said optimum production quantity.